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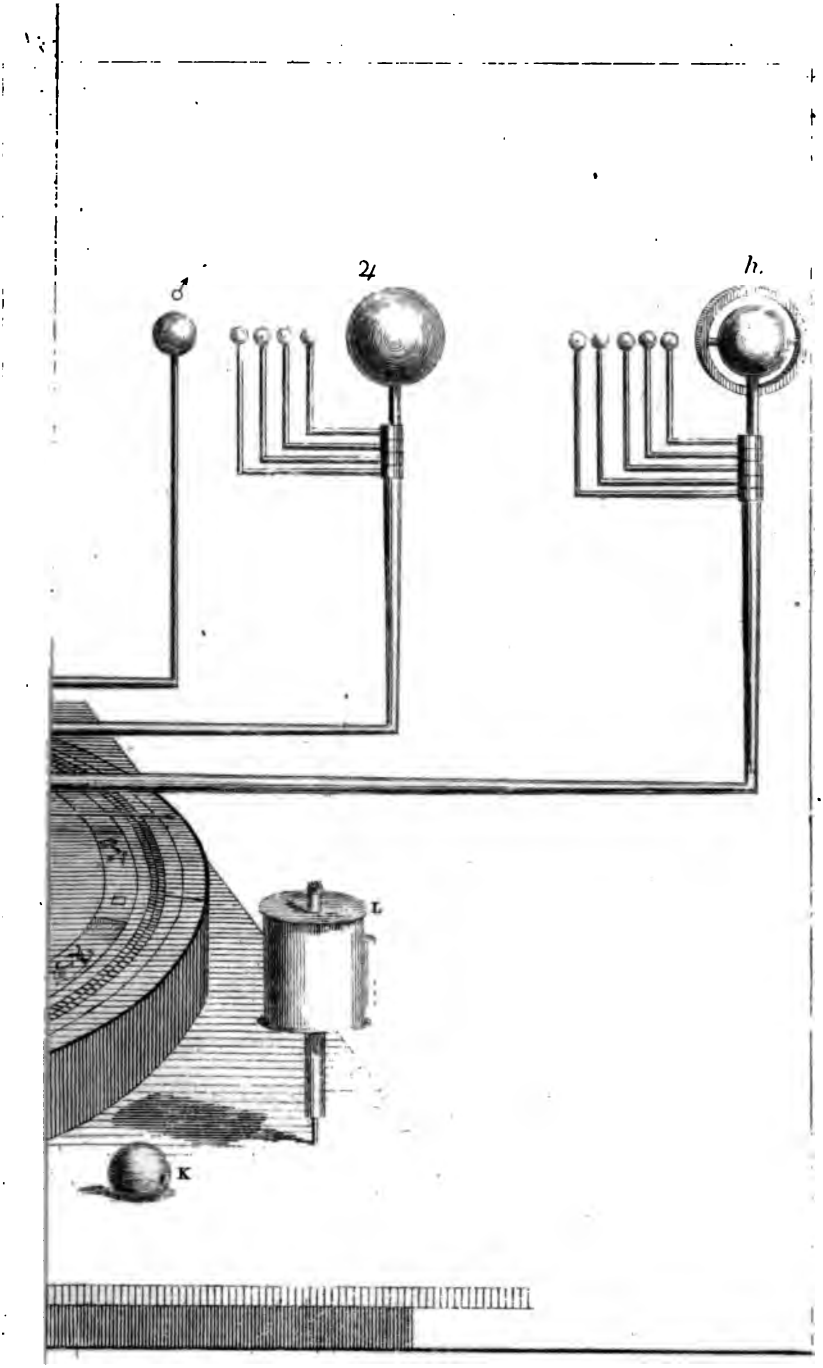

LLIAM JONES.

ery is applied to the Board.

e, his Ring and five Moons.

THE
DESCRIPTION AND USE
OF A
NEW PORTABLE
ORRERY;

On a moſt ſimple Conſtruction,
Repreſenting in Two Parts—The Motions, and
Phænomena of the

PLANETARY SYSTEM;

But more particularly the Motions of the Earth and Moon, round the Sun, from whence the Nature and Cauſes of the viciſſitudes of the Seaſons, Days, and Nights, Solar and Lunar Eclipſes, &c. are clearly explained.

To which is prefixed,

A ſhort Account of the SOLAR SYSTEM, or the true
SYSTEM of the WORLD.

The SECOND EDITION, Enlarged, with an Account of the New diſcovered Planet, called the Georgium Sidus, and Embelliſhed with a new Copper Plate of the Inſtrument.

By WILLIAM JONES,

LONDON:
Printed for the AUTHOR, M,DCC,LXXXIV.

PRICE ONE SHILLING.

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PREFACE.

THE favourable Reception the Orrery has met with from Perſons of the firſt diſtinction, and from Gentlemen and Ladies in general, has induced me to add to it ſeveral new improvements in order to give it a degree of Perfection, and diſtinguiſh it from others; which by Piracy, or Imitation, may be introduced to the Public. The two principal additions are a New and Elegant Engraved Plate for the Board on which the Inſtrument moves; ſhewing by inſpection the proportional diameters of the Planets, diſtinguiſhed by their proper Characters, including the new diſcovered Planet, and a repreſentation of the appearance of a Comet. The other addition is a Planetarium, or a ſet of Planetary arms, to ſcrew on the Board in room of that Part which has the Earth and Moon only, as ſhewn in the Plate prefixed to this: in fact, I have as far as ſimplicity and cheapneſs, (which are the two great advantages of the Inſtrument) would permit me, endeavoured to complete it for the better introduction of young Gentlemen and Ladies to the moſt pleaſing, ſublime and uſeful of all Sciences, *Aſtronomy.*

Part of the Orrery deſcribed in the following Pages, is conſtructed nearly upon the principle of thoſe contrived by the late ingenious Mr. Ferguſon; and the Orrery having only four Wheels, and two Pinions, to ſhew all the Phænomena it explains, recommends itſelf to the Public for ſimplicity and cheapneſs; particularly to Maſters and Governeſſes of Boarding Schools, Private Tutors, &c. For by putting ſuch an Inſtrument as this into the Hands of their Pupils, they will acquire more knowledge of the moſt uſeful and intereſting part of Aſtronomy in one Day, than by the ſtudy of Books in a conſiderable Time.

My reaſon for prefixing a ſhort Account of the Solar Syſtem, is obvious; it is to prevent the unlearned Tyro the trouble and expence of turning to Volumes on Aſtronomy, to be informed of that only which no Orreries (with conveniency) can proportionally repreſent, viz. the Diameters and Diſtances of the Primary and Secondary Planets there repreſented.

The few lines on the Diſcovery of the new Planet, will not I preſume be unacceptable; as they were inſerted for the information of thoſe Readers who have heard much concerning it, but have no opportunity of peruſing the Accounts lately publiſhed in the Tranſactions of the Roval Society, &c.

To conclude; the Candor and Forgiveneſs of the Reader is here intreated for Errors or Imperfections he poſſibly may diſcover in the following Pages, as they are the production of one, whoſe engagements in buſineſs will admit but a ſmall portion of time for an endeavour to explain the moſt conſpicuous, and intereſting Phænomena of the Heavenly Bodies, by his New Portable Orrery.

* * *

THE

DESCRIPTION AND USE

OF A

NEW PORTAALE

ORRERY, &c.

PART I.

A ſhort Account of the Solar Syſtem.

I. IT has been indiſputably proved by ſeveral eminent Aſtronomers, and is now univerſally allowed that the Earth is a Planet, and with its Attendant the Moon, revolves round the Sun, as a central body by the ſame cauſe as the other revolving Planets, Mercury, Venus, Mars, Jupiter, and Saturn; viz. an attractive power in the Sun, conjoined with a projective force, or a motion perpendicular to the Sun's attractive or central power; well repreſented by the motion of a Stone in a ſling, where the motion that is given to the ſling, is the Projectile

Force, and the ſling that prevents the Stone from flying off, the attractive power of the Sun; alſo, that the paths (called Orbits) which they deſcribe are not circular, but rather elliptical, and more, or leſs ſo, according to the adjuſtment of the above two powers.

2. As that ſyſtem of the heavenly bodies which has the Sun for it's center, is called the Solar Syſtem, I ſhall immediately proceed to give a ſummary deſcription of the ſeveral bodies that compoſe it, and ſuch particulars of each as are the moſt remarkable; annexing at the ſame time a conciſe deſcription of the fixed Stars from the accounts of modern Aſtronomers, who to their honor and credit be it ſaid, have ſpared no expence or pains to render the knowledge of the conſtituent partsof the univerſe familiar and eaſy:

3. The Solar Syſtem, or the Syſtem of the Planets I am now going to deſcribe, is, of all the different ſyſtems that have been invented, the moſt ancient, and the moſt rational to an unprejudiced conſiderer, for we are informed that it was invented and taught by the famous Greek Philoſopher, Pythagoras, who flouriſhed about 500 years before Chriſt, and by ſeveral of his followers; but being loſt in the prejudices of ſenſe and opinion, until about 300 years ago, when it was renewed and ſupported by the famous Poliſh Philoſopher, Nicholas Copernicus, who was a Native of Thorn. In this he was followed and confirmed by the moſt renowned Mathematicians and Philoſophers that have ever flouriſhed; as Kepler, Galileo, Deſcartes, Gaſſendus, and the incomparable Sir Iſaac Newton, who has eſtabliſhed this ſyſtem on ſuch a permanent baſis of truth and demonſtration, as to reſiſt all the efforts of ignorance and error: and from the above philoſophers it has received the various names of the Pythagorean, Copernican, and

Newtonian ſyſtem, but now the Solar or true Syſtem of the World.

4. There were two ſyſtems generally believed at the time of the obſcurity of the Solar Syſtem, one by Ptolemy, an Egyptian Aſtronomer, ſuppoſed to live 138 years before Chriſt: The other by a noble Dane, named Tycho Brahe born in Schonen, A. D. 1546.

5. The Ptolemaic Syſtem, ſuppoſed the Earth to be immoveably fixed in the center of the univerſe, and about which moved the ſeven Planets, viz. the Moon Mercury, Venus, the Sun, Mars, Jupiter, and Saturn, beyond theſe the firmament of ſtars, then two chryſtalline ſpheres, all of which receive motion from the Primum Mobile, or firſt mover, which revolved about the Earth in 24 hours from eaſt to weſt. But as this ſcheme was only agreeable to appearances, and incapable of ſtanding the teſt of art and obſervation, it was rejected as a combination of errors and abſurdities.

6. The Tychonic Syſtem, * was invented after the Ptolemaic, but was never ſo general; this ſuppoſed the Earth to be the center of the firmament of Stars, as alſo the two luminaries the Moon and the Sun; but it ſuppoſed the Sun to be the center of the planetary motions, viz. of Mercury, Venus, Mars, Jupiter, and Saturn; theſe with the Sun revolved about the Earth to account for the annual or yearly motion, and the Earth revolved about its axis every 24 hours from weſt to eaſt, to account for the apparent diurnal or daily motion of the heavenly bodies from eaſt to weſt.

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* The Tychonic and Copernican Syſtems are both familiarly repreſented in the Planetarium parts of the Orrery.

This hypotheſis being in part true, and in part falſe, was embraced by few, and ſoon ſurrendered to the only rational or true ſyſtem reſtored by Copernicus, and demonſtrated by Sir Iſaac Newton, viz.

The Solar Syſtem,

Which has the Sun for its center, and the Planets with their Satellites or Moons, and Comets, revolving round him in the following order, beginning firſt with

7. The Sun, an immenſe globe of fire from which all the planets receive their light and heat, computed to be above 800,000 Miles in diameter, and if ſo his bulk muſt be a million times greater than our Earth.

8. Mercury, the firſt planet in the ſyſtem, at the diſtance of 32 million of miles, revolves about the Sun in 87 days and 23 hours. Its diameter is computed to be 2600 miles, and its light and heat ſeven times greater than ours.

9. Venus, the ſecond planet, which at the computed diſtance of 59 millions of miles, revolves about the Sun in about 224 days, 17 hours. Her diameter 7906 miles, and light and heat twice as great as ours, and is the moſt brilliant planet of any in the Heavens, frequently ſhewing herſelf in the day time:

10. The Earth, or that planet on which we live, is the third planet in order from the Sun, and is at the diſtance of 90 millions of miles from it; its revolution about the Sun is in 365 days, and 6 hours, moving at the rate of 58000 miles every hour. This motion cauſes the Sun to appear to move round, in the Heavens in that time; alſo it has another motion round an imaginary line, called its axis, every 24

hours, from weſt to eaſt, which cauſes an apparent diurnal motion of the Heavens from eaſt to weſt: by this ſwift motion of the Earth on its axis, the inhabitants of London are carried 580 miles every hour, beſides the 58000 miles by the yearly motion abovementioned. The earth is 7960 miles in diameter, and is the firſt planet in the ſyſtem that is attended by a Moon, or Satellite.

11. The Moon, an attendant of the Earth, revolves about the earth from change to change, in 29 days and 12 hours, at the diſtant of about 240,000 miles, and is about 2175 miles in diameter, and therefore about 50 times leſs than the Earth. From the motions of the Earth and Moon round the Sun, and from the various ſituations of the Sun, Earth, and Moon, in reſpect to each other ariſe the viciſſitudes of the Seaſons, Days, and Nights, Eclipſes, &c. which, and their cauſes the Orrery hereafter to be deſcribed, will evidently repreſent.

12. Mars, the fourth planet from the Sun, at the diſtance of 123 millions of miles, circulates about the Sun in 687 days, being 4444 miles in diameter, and always having a red or fiery aſpect.

13. Jupiter, the fifth planet, is the largeſt of all the planets, being no leſs than 81000 miles in diameter, and therefore a thouſand times bigger than the Earth, revolves about the Sun in about 12 years, at the diſtance of 424 millions of miles; and is attended with four Moons ſimilar to that of the Earth's, their diſtances and periods being as follow; the firſt Moon at the diſtance of 229,000 miles from his center, goes round him in one day 18 hours and 36 minutes; the ſecond, at 364,000 miles, in 3 days 13 hours and 13 minutes; the third, at 580,000 miles, in 7 days 3

hours and 59 minutes; and the fourth, or laſt, at 1,000,000 of miles, in 16 days, 18 hours, and 30 minutes.

14. Saturn, the moſt diſtant of the ſyſtem, being about 780 millions of miles from the Sun, and revolves about him in nearly 30 years; its diameter is about 68,000 miles, and it is encircled with a very large ring, at the diſtance of 20,000 miles, which is alſo the breadth of the ring; it is attended by 5 Moons, the diſtances and periods of which are as follow; the firſt, at the diſtance of 140,000 miles, goes round him in one day 21 hours and 19 minutes; the ſecond, at 187,000 miles, in 2 days 17 hours and 25 minutes; the third, at 263,000 miles, in 4 days 12 hours and 25 minutes; the fourth, at 600,000 miles, in 15 days 22 hours, and 41 minutes; and the fifth, or laſt, at 1 million, 800,000 miles, in 79 days, 7 hours and 40 minutes.

15. In conſequence of a recent diſcovery, we muſt make an innovation in our ſyſtem, for ſeveral of our preſent eminent Aſtronomers, have ſuggeſted to us the idea of a new Planet, from ſome obſervations made, and communicated to them by Mr. Herſchel, of Bath, in the Philoſophical Tranſactions for the years 1781, 1782, 1783, or Vol. 71, 72, and 73. A comprehenſive account of this diſcovery is likewiſe given in the improved London Magazine for 1783, page 17, &c. including the calculations, and obſervations of the Mathematicians, from which the following is extracted.

"Mr. Herſchel has for many years applied himſelf to the conſtructing of Reflecting Teleſcopes for his amuſement, and has ſucceeded ſo far, that he makes them to bear magnifying powers of an almoſt incredible bigneſs—not leſs than between ſix and ſeven thouſand times! The effect which theſe very large magnifying powers had on the appearance of the fixed ſtars, in ſhewing many to be double, triple, and even quadruple, which were before thought to be ſingle ſtars, ſuggeſted to Mr. Herſchel the idea of attempting to diſcover the parallax of the fixed ſtars by their means."

" It was in purſuit of this object that Mr. Herſchel was examining the ſmall ſtars near the feet of Gemini, on the 13th of March, 1781, between the hours of ten and eleven at night, when he took notice of one viſibly larger than the reſt, being ſtruck with its uncommon magnitude, he compared it with H. Geminorum; and the ſmall Star in the quadrangle, between Auriga and Gemini, and finding it ſo much larger than they, tho' not quite ſo brilliant, began to ſuſpect that it was a comet. To determine this point, he examined it with different magnifying powers, from 722, the power with which he diſcovered it, to 2010; and found continually, that the diameter of the Comet (as he ſuppoſed it to be) encreaſed in proportion to the power; contrary to what is univerſally known to be the caſe, when different magnifying powers are applied to the fixed ſtars; But in order to obtain abſolute certainty in this point, he meaſured its diſtance from ſome of the neighbouring fixed Stars, with which he compared it again a night or two afterwards, and then found it was changing its ſituation at the rate of about 2 ¼″ in an hour."

" Aſſured of this, Mr. Herſchel wrote immediately to the Royal Society, informing them of his diſcovery, that other Aſtronomers might join in the obſervation of it: but not mentioning, in his firſt letter, that it was neceſſary to uſe a very large magnifying power, to diſtinguiſh it from a fixed Star, they did not immediately diſcover it. This point being, however

ever, explained, the Aſtronomer Royal, as well as profeſſor Hornſby, of Oxford, detected it immediately; and the former almoſt ,as ſoon as he ſaw it declared his ſuſpicions (extraordinary as the caſe ſeemed,) that it was not one of that ſpecies of bodies which we ordinarily call Comets, but a planet belonging to our ſyſtem, of the ſame nature with the reſt, although on account of its ſmall ſize and remote ſituation, it had eſcaped the obſervations of Aſtronomers to this time,"

The deſign of this pamphlet will not admit the inſertion of the ſeveral obſervations, and calculations of other Mathematicians, and Aſtronomers, which were made in order to determine its revolution, diameter, diſtance, &c. but the reader may ſee an excellent account of them in the work referred to above.

The ſituation and time of this New Planet's motion, being determined, Aſtronomers ſet about calculating the time of its revolution, diſtance from the Sun, diameter, elements of its orbit, &c. Accordingly, the computations of Mr. Lexell, Mr. De La Lande, (the great French Aſtronomer) and others, make its orbit nearly circular, the time of its revolution 82 years, that it moves at the rate of 43 ſeconds per day, its apparent diameter about 3 or 4 ſeconds, its real diameter about 4 ½ times of the Earth, and its real diſtance near 1800,000,000 miles from the Sun.

Mr. Herſchel concludes his laſt paper in the 1ſt. part of Vol. 73 of the Philo. Tranſactions with " Thus much, however, we may in general ſurmiſe that the diameter of the Georgium Sidus cannot well be much leſs, nor perhaps much larger than about four ſeconds. From this, if we will anticipate more exact calculations hereafter to be made; we may gather that the real diameter of that planet muſt be between four and five times that of the Earth; for by the calculations of M. De. La Lande, contained in a Letter he has favoured me with, the diſtance of the Georgium Sidus is ſtated at 18,913, that of the Earth being 1. And if we take the latter to be ſeen under an angle of 17″, it would ſubtend no more than '898″ when removed to the orbit of the Georgium Sidus. Hence we obtain $\frac{4}{,898}$—4'454 which number expreſſes how much the real diameter of the Georgium Sidus exceeds that of the Earth," from which we may infer that its real diameter is 36,000 miles, and its diſtance 1800,000,000 miles as above

"This planet appears very ſmall, when viewed with the naked eye, or a Teleſcope of a ſmall power, is not greatly different from that of a fixed Star of the fifth, or ſixth magnitude, being ſomewhat leſs bright than No. 132 of Taurus in Flamſtead's Catalogue; but when examined with a good Teleſcope, which magnifies 200 times, or upwards, it is far otherwiſe; as it then appears under a ſenſible diameter, and its light is more diluted than that of the fixed Stars."

It gives me peculiar ſatisfaction to acquaint the Reader. that it has received its name by the diſcoverer, from one of the nobleſt of actions, namely Gratitude; for as he obſerves "Poſterity will receive great ſatisfaction in being informed, that this laſt found Planet was diſcovered in the reign of George the Third; and that the name of Georgium Sidus, will ſufficiently convey the information of the time and country, when and where it was firſt brought to view," that is, in the reign of one of the beſt of Monarchs, who, from his excellent bounty, and earneſt deſire of rendering the lives of thoſe comfortaable and eaſy, who labour to the advancement of ſciences, has patronized the ingenious diſcoverer of this new phænomenon.

16. Of all human predictions, thoſe of the Aſtronomers are the moſt infallible, witneſs, their calculating the time of Eclipſes, Tranſits, Periods of the Planets, &c. conſequently the utmoſt confidence ought to be placed in their deciſions; and we ought not to ſneer at the idea of a new Planet, or other Phænomena, on account of immenſe diſtance, or imperceptibility; for there's no doubt but the Satellites of Jupiter and Saturn, were as much diſbelieved at the time of their diſcovery, as the exiſtence of another Planet may be at preſent; if future obſervations, ſhould confirm, that it has all the properties of the other Planets, we may, without any extent of imagination receive it into our Syſtem, as one acting with the reſt in the Cœleſtial exhibition of nature.

17. There are another kind of Planets moving round the Sun, beſides what have been juſt deſcribed, called Comets, which are ſuppoſed to be ſolid opaque bodies, with long fiery tranſparent tails, iſſuing from that ſide which is oppoſite to the Sun, and to move in very excentric or oval orbits, and are amazingly heated by their near approach to the Sun, for according to Sir Iſaac Newton, the Comet that appeared in 1680, when neareſt to the Sun, was 2000 times hotter than a red hot iron, and retains its heat until its return again, which is in 575 years. This Comet at its greateſt diſtance from the Sun was computed to be 11000 and 200 millions of miles diſtant, and at its neareſt diſtance 490,000 miles, moving in its orbit with the velocity of 800,000 miles every

hour. * The number of Comets belonging to our ſyſtem, is uncertain, as they ſo ſeldom fall under the obſervation of Aſtronomers, having ſuch very long periods, and attended by ſuch different appearances, but by the beſt accounts we are informed there is about 21, and that the periods of three only are known.

Having now got to the limits of our ſyſtem we ſhall proceed to the Orrery, after giving an explication of thoſe bodies in the Heavens, which have no connection with our Planetary Syſtem, (as many do ſuppoſe) but appear fixed, from whence they are called,

18. The fixed Stars, which are thoſe luminaries above our heads that in the abſence of our Sun conſtitute the ſpangled canopy of the Heavens; and are ſuppoſed by modern Aſtronomers to be Suns, made for the ſame purpoſes as our Sun, each to beſtow light, heat, and vegetation, on a certain number of inhabited planets, kept by gravitation within the ſphere of its activity,

19. The number of the Stars, including thoſe that cannot be ſeen without the Teleſcope, is infinite; but thoſe that are viſible by our naked eyes, limited; for, in a clear winter's night, without moonſhine, there is not to be diſcerned above 1000, as any perſon may convince himſelf by applying to a good Cœleſtial Globe, where he will ſee all the Stars, divided into parcels or conſtellations, having particular names to each, by which they may eaſily be diſtinguiſhed in the Heavens. The white path ſeen among the Stars,

is

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* See Ferguſon's Aſtronomy, or Martin's Young Gentleman's and Lady's Philoſophy, in 3 Vols. Octavo. two excellent Treatiſes for eaſily introducing Learners to a knowledge of the Heavens,

is called the Galaxy, or milky way, and is ſuppoſed to be an innumerable quantity of Stars, which by their combined luſtre cauſe the white appearance that it is attended with. The diſtance of the Stars from the Earth, and alſo from each other, is ſuppoſed to be immenſurably great, for one of the largeſt and moſt brilliant Stars in the Heavens, thought to be the neareſt of any to us, called Sirius, is calculated to be at no leſs a diſtance than 2,200000,000000, viz. 2 billions and 2 hundred thouſand millions of miles, and that a cannon ball diſcharged from the Earth with the velocity of 480 miles an hour, would not arrive at it in leſs time than 700,000 years. Thoſe Stars that appear the largeſt, and have the greateſt luſtre, are called Stars of the firſt magnitude; the next in luſtre, Stars of the ſecond magnitude; and ſo on to Stars of the ſixth magnitude, which are the ſmalleſt that can be diſcerned by the bare eyes in a clear ſtar-light night. The vehement twinkling of the Stars is occaſioned by the tremulous motion of particles in the Air, for the Stars appearing like points, will by every intervening opaque particle in the Air be eclipſed, every now and then, ſo as to cauſe a ſcintillation or twinkling, but the planets appearing larger can ſuffer no ſuch occultation, hence, here is a certain method of diſtinguiſhing the Planets from the Stars: The apparent daily motion of the Stars from eaſt to weſt, ariſes from the real motion of the Earth on its axis, and the different ſets of Stars that we ſee at different times of the year, from the real motion of the Earth in its orbit (ſee § 10) which with the daily motion will be clearly ſhewn in the Orrery. There are ſeveral other curious particulars of the Stars which this ſmall treatiſe will not admit me to enlarge upon, but are fully explained by the Authors before mentioned in note to § 15.

19. Upon a reflection on the nature and properties of the fixed Stars here communicated to us, what an amazing, exquiſitely grand, and ſublime idea does it afford us, of the ſtructure of the univerſe, not compoſed of one Sun, and one World, as the ignorant in Aſtronomy conceive, but conſiſting of ſuch an inconceivable number of Suns, Syſtems, and Worlds, diſperſed through the infinite abyſs of ſpace, that if our Sun, with all the Planets, Moons, and Comets, appertaining thereto were annihilated, they would be no more miſſed by a perſon who could ſurvey the whole Creation, than a grain of ſand from the ſea-ſhore, the ſpace they occupy being comparatively ſo minute, that it would ſcarce be a ſenſible blank in the univerſe, notwithſtanding Saturn, the moſt diſtant of all the Planets, revolves about the Sun in an orbit of 4,884 millions of miles in circumference, and ſome of our Comets make excurſions upwards of 10,000 millions of miles beyond Saturn's orbit, and yet at that amazing diſtance, they are incomparably nearer to the Sun than any of the Stars, and return periodically by the efficacy of the Sun's attraction.

20. And do not thouſands and thouſands of Suns, multiplied without end, and ranged all around us at immenſe diſtances from each other, * attended by ten thouſand times ten thouſand Worlds, all in rapid motion, yet calm, regular, and harmonious, invariably performing the paths preſcribed them; Worlds, peopled with Myriads of intelligent beings, formed for

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* So great are the diſtances of ſome of the Stars ſuppoſed to be, that Mr. Huygens, a celebrated Aſtronomer, ſuggeſted that the light of many of them had not yet reached the Earth, ſince its creation.

endleſs progreſſion in perfection, and felicity: Does not this, I ſay, evidently convince us of the exiſtence of a Deity? the ſuperlative greatneſs, the infinite wiſdom, and the paternal goodneſs of whom, is moſt glorioufly diſplayed in this ſtupendous fabric of the univerſe.

21. What an abundance of delight and rational pleaſure then, is to be obtained by the ſtudy and contemplation of the works of the Creator? and how much approbation and encouragement do thoſe contrivances deſerve, the deſign of which is to facilitate ſuch uſeful knowledge to the underſtandings of the youth of both ſexes? making them both wiſe and happy, not vainly ſpending their precious and irrevocable time in the idle and prophane amuſements of the age, but enjoying it by reſearches into the unbounded field of nature, which will unavoidably lead them to confeſs with the Pſalmiſt, that "'tis God " who hath laid the foundation of the Earth, and " that the Heavens are the work of his hands."

22. Having now finiſhed the ſhort account of the Solar Syſtem, deſigned to convey ideas of that part of Aſtronony which Orreries (with conveniency) cannot proportionally repreſent, viz. the proportional diſtances and diameters of the primary and ſecondary Planets, we muſt proceed to the deſcription of the Orrery, which will, to any perſon beſtowing the leaſt attention on it, greatly familiarize thoſe phænomena of the univerſe it is intended to repreſent.

End of Part the Firſt.

THE DESCRIPTION AND USE OF A NEW PORTABLE ORRERY,

On a moſt Simple Conſtruction, &c.

PART II.

1 TO any perſon ever ſo little acquainted with the ſcience of Aſtronomy, the ſtructure of the Orrery, and its uſes are evident by only a bare inſpection; but for the benefit of thoſe totally unacquainted with the ſcience, it will be neceſſary to give as intelligible a deſcription as poſſible, previouſly deſiring the learner to pay no reſpect to the diſtances and diameters of the Planets, there repreſented, but for information in that point ſee § 7 to § 15, Part I.

2. The Orrery conſiſts of two Parts, one part having all the Planets and their Satellites; and the other only the Earth and Moon, with a ſet of wheels to ſhew the particular Phænomena reſpecting the Earth and Moon only,

3. The board on which the Machines turn, has paſted on it a new printed paper, coloured and varniſhed; near the outward edge of which are ſeveral circles: The firſt or outward circle is divided into the twelve months of the year, and the next into their reſpective days; the two inmoſt circles have the twelve ſigns of the Zodiac, with their proper characters and names, each ſign containing 30 degrees, or the whole 360°: this ecliptic circle repreſents that path in the Heavens, which the Sun ſeems to deſcribe in a Year, it being properly the path of the Earth round the Sun: (ſee § 10. Part I.) In this ecliptic circle are four letters N. W. S. E. ſignifying the North, Weſt, South, and parts of the Heavens.

It has alſo four diviſions made by lines drawn from the firſt degree of Cancer, the firſt degree of Capricorn, the firſt degree of Aries, and the firſt degree of Libra; between theſe four lines are written the four Seaſons of the Year, the lines denoting their Beginning, Duration, and End, and along theſe four lines are written the length of day and night, and the diſtinction of the Equinoxes.

The inner circle contains a view of the diameters of the Planets, in proportion to each other, and to that of a Globe the diameter of the board for the Sun; among them is the new diſcovered Planet, the Georgium Sidus, of the comparative ſize now eſtimated; (ſee § 15. Part I.) and a ſmall repreſentation of the appearance of a Comet.

4. For the ſake of diſtinguiſhing one part of the Orrery, from the other; we will call that which has all the Planets repreſented, the *Planetarium*, and the other which has the Earth and Moon only, the *Tellurian*.

5. Before we proceed to the deſcription of the Planetarium, it will be neceſſary to learn how to apply it to the board for uſe. After taking the Orrery out of the boxes it uſually is packed in, you muſt take hold of a round turned ſhoulder or pillar, under the board with your left hand, and the wheel A. B. of the frame of wheels (ſee the Plate) with your right, then turn the board round in a direction from you, or that way which is uſual in unſcrewing, and that part will be unſcrewed; then taking up the Planetarium at the part S. ſcrew it on by the contrary motion of the board, that the other was unſcrewed by, taking care that it is ſcrewed up quite tight. For a view when applied ſee the plate.

6. The Planetarium being now properly fixed to the board, we muſt attend to its parts and uſe.

The Ball (☉) in the center repreſents the Sun in the center of the ſyſtem; next are the Planets Mercury (☿), Venus (♀), the Earth ⊖, and Moon ☽, Jupiter (♃) and his four Moons; Saturn (♄), his ring and five Moons; now as they are diſtinguiſhed in general by theſe characters, the learner ſhould know them by heart, and for that purpoſe, the names with the characters prefixed are inſerted at the bottom of the plate.

7. The braſs ball for the Sun, is ſometimes taken off the center, and a ſmall tin lamp L. is placed in the room of it, by a ſide ſocket, which is made to fit the center piece.

8. The ſmall braſs ball K. is occaſionally placed where the Earth is, and the Earth placed on the cen-

ter where the large braſs Sun is. This ſmall braſs ball is to repreſent the ſituation of the Sun in the Ptolemaic Syſtem. See § 5. Part I.

9. The arms of this Planetarium are moved only by the hand, yet the principal Phænomena may be eaſily repreſented; to the exhibiting of which, we will proceed with a view of the demonſtrative proof of the falſity of the Ptolemaic Hypotheſis (§ 5. part 1ſt.)

10. Place the Earth on the center, and the ſmall Sun K. in the place of the Earth, then by moving *Mercury*, and *Venus*, round the Earth in this Syſtem, you will plainly ſee (1.) That theſe two Planets, being both within the orbit *of the Sun*, cannot be ſeen at any time to go behind it; whereas we obſerve them as often to go behind, as before the Sun in the Heavens: (2) It ſhews that as the Planets move in *Circular Orbits* about the Central Earth, they ought at all times to be of the *ſame apparent Magnitude*; whereas on the contrary, we obſerve their apparent Magnitude in the Heavens to be greatly variable, and ſo far different, that *Mars* will ſometimes appear nearly as large as *Jupiter*, and at other times ſo ſmall, that you can ſcarce know him from a *fixed Star*. (3.) It ſhews, that any of the Planets might be ſeen *at all diſtances* (from the Sun) in the Heavens, or in other Words, that when the Sun is in the Weſt (ſetting), *Mercury* and *Venus* may not only be ſeen in the *South*, but even in the *Eaſt* (riſing); which poſitions were never yet ſeen by any perſon. (4) You ſee by *moving* the Planets, that their Motions would be always regular and *uniformly the ſame*; whereas, on the contrary, we obſerve them always to move with a variable velocity, ſometimes *faſter*, then *ſlower*, and ſometimes *not at all*. (5 By the moving of them as above, the Planets mov all the *ſame way*; viz. from *Weſt* to *Eaſt*, continually

But in the Heavens we ſee them move ſometimes *direct* from *Weſt* to *Eaſt*, ſometimes *Retrogade* from *Eaſt* to *Weſt*, and at other times to be *ſtationary*. All which *Phænomena* plainly prove the Syſtem, to be a *falſe* and *inconſiſtent Hypotheſis*.

11. On the contrary, the truth of the *Copernican*, or Solar Syſtem (§ 7.&c. part 1.) which has the Sun in the Center, and the Earth among the Planets, is hereby moſt clearly repreſented. For taking the Earth from the center, and replacing it, and putting the large Sun ⊙ again on the center, then every thing will be right, and agree with Cœleſtial obſervations; for by moving the Planets as before, (1.) You will ſee the Planets *Mercury* and *Venus* (as viewed from the Earth), go *before* and *behind* the *Sun*, or have two Conjunctions. (2) You will obſerve *Mercury* never to be more than 21°, and *Venus* 47°, from the Sun. (3) That the Planets, and eſpecially *Mars* will be ſometimes much *nearer* to *the Earth* than at others, and therefore muſt appear *much larger* at one time than at another. (4) You will ſee that the Planets cannot appear at the Earth to move with an uniform velocity; for when *neareſt* they appear to move *faſter*; and ſlower when moſt *remote*. (5) You will obſerve the Planets will appear at the Earth to move ſometimes directly from *Weſt* to *Eaſt*; then to become *Retrogade* from *Eaſt* to *Weſt*, and between both to be *Stationary*, or without any apparent Motion at all, which things all correſpond exactly with Obſervations, and fully prove the Truth of this excellent Syſtem.

During the above we ſuppoſed, for clearneſs ſake, that the Earth was motionleſs, in a line in or near the South, S. of the ecliptic; but the Phænomena would happen juſt the ſame if the Earth was in motion; their times and duration being only different.

12. Theſe few Phænomena of the Planetary Syſtem lead us to the method of ſhewing the Places, and relative aſpects of the Planets; found by an Ephemeris for every day in the Year.

13. The Ephemeris is a Diary, or daily account of the places of the Planets, as they appear to the Eye placed both at the Sun, and at the Earth, throughout the Year, called their Heliocentric, and Geocentric Places; that being the Heliocentric place as ſeen from the Sun, and that the Geocentric as ſeen from the Earth. As an example, for finding the places, we will ſuppoſe the Ephemeris, (by White) at hand, where at the bottom of the left hand page for every month is the Heliocentric Longitudes, (or places) of all the Planets, to every ſix days of the month, near enough for common uſe; a copy of the table is here inſerted for the conveniency of the learner; it is for March, 1784; now for an example.

Days	Day increaſ.	Helioc. long. ♄	Helioc. long. ♃	Helioc long. ♂	Helioc. long. ⊖	Helioc. long. ♀	Helioc. long. ☿
1	3 11	16 ♑ 45	17 ♒ 11	1 ♋ 30	11 ♍ 37	9 ♐ 35	7 ♏ 58
7	3 35	16 56	17 43	4 23	17 37	10 7	25 23
13	3 59	17 7	18 15	7 15	23 36	19 38	11 ♐ 59
19	4 23	17 17	18 47	10 6	29 33	29 8	28 33
25	4 47	17 28	19 19	12 55	5 ♎ 30	8 ♑ 38	15 ♑ 49

We will ſuppoſe, that we want for the Planetarium, the Heliocentric places of the Planets, on the 21ſt, looking at the table we take the 19th Day; which is the neareſt, to the day wanted: then the place of Saturn (♄) is in 17°. 17'. or 17 degrees, (rejecting the minutes) of Capricornus ♑; of Jupiter (♃) in 18° of Aquarius (♒); of Mars (♂) in 10° of Cancer (♋)

of the Earth (Θ) in 29° of Virgo (♍); of Venus (♀) in 29° of Sagittarius (♐); and of Mercury (☿) in 28° of the ſame ſign; and ſo on for any other day there ſpecified. Upon this depends a very pleaſing *Aſtronomical Praxis*, by which you may at any time be able to entertain yourſelf in a moſt rational and agreeable manner; that is to ſay, you may in a minute or two, repreſent to yourſelf the true appearance of the Planetary Syſtem, juſt as it really is in the Heavens, for any day you pleaſe, by aſſigning to each planet its proper place in its Orbit, as in the following manner, for the 29th of March as before; the place of Saturn is in 17° of Capricornus (♑); now, taking hold of the arm of Saturn, in the Planetarium, I bring it over the 17° of Capricorn, on the Ecliptic circle of the board; thus doing the ſame for the other Planets, they will have their proper Heliocentric places for that day.

14. Now at this ſituation of the Planets, we obſerve, that if a perſon was placed on the Earth, he would ſee Venus and Jupiter in the ſame line, conſequently in the Heavens they would appear together, or in conjunction; Mercury a little to the left, or eaſtward of them, and nearer to the Sun: Saturn to the right, or the weſtward farther from the Sun: Mars directly oppoſite to Saturn; ſo that when Saturn appears in the Weſt, Mars appears in the Eaſt, and vice verſa. There are many other aſpects evident by the learner's inſpection, and if you compare them to the Planets in the Heavens, they will be found to correſpond exactly: theſe are the Geocentric places. Several other curious and entertaining particulars may be obſerved, as depending on the above, and eaſily be repreſented by the learner, as his progreſs in

Aſtronomy encreaſes; one in particular is worth noticing: If the Planetarium is ſet by a white wall, and the Lamp placed thereon, lighted with oil, and a very ſlender wick of cotton; then by moving the ſatellites of Jupiter and Saturn round the Planets, the projection of their ſhadows will ſhew the reaſon why thoſe Moons always appear on each ſide of Jupiter, and Saturn in a right line; why theſe which are moſt remote, appear neareſt and vice verſa.

15. Thus I have endeavoured to point out to the learner the way of exhibiting the principal and moſt entertaining Phænomena of the Planetary Syſtem, which may be called the firſt and fundamental Principles of Practical Aſtronomy; and prepares the Pupil to enter on another intereſting and uſeful part, viz. the knowledge of the nature and cauſes of the viciſſitudes of the Seaſons, Days and Nights, Eclipſes, &c. the explication of which is ſeen by the other part of the Orrery, namely the Tellurian. The manner of applying which is the ſame as the Planetarium. ſee § 5.

16. The Tellurian being ſcrewed faſt to the board, the braſs ball repreſents the Sun as before.

The Ivory Ball, with ſeveral circles cut on it, denotes the Earth, and the braſs pin that it is ſupported on, the Axis of the Earth; this braſs pin has an inclination to the board on which it goes round, thereby giving the Earth its proper poſition, called by Aſtronomers, the inclination of the Earth's Axis to the plane of the Ecliptic. This poſition never varies, and is therefore termed the Earth's paralleliſm to itſelf: It is this invariable poſition of the Earth, that cauſes the viciſſitudes of the Seaſons, and the different length of days and nights.

The

17. The top of the pin on which the Earth turns is called the North Pole, the bottom the South Pole; the two circles near theſe two Poles are termed Polar Circles, the upper one the North Polar Circle, and the under one the South Polar Circle; the two circles next to theſe are called the Tropics, the upper, the Tropic of Cancer, the under, the Tropic of Capricorn; the circle in the middle between the Poles is called the Equator, becauſe it equally divides the Earth; for when the Sun is over that part of the Earth, it is equal Day and Night all over the Globe. There is another circle, which croſſes the Equator, and touches the Tropics in two points; this circle repreſents the path over the Earth that the Sun makes in a year, and is called the Ecliptic.

18. There are twenty-four other circles, called Meridian Circles, all meeting at the Poles, and croſſing thoſe juſt mentioned, theſe anſwer to the twenty-four hours of the day, in which time the Earth turns once round its Axis, making one day and one night, as will be ſhewn hereafter.

19. There is a ſmall piece of braſs put on the Earth, nearly between the upper Tropic and Polar Circle, (ſee the plate) which repreſents the place of London on the Earth, by which the various changes that this metropolis undergoes is more clearly ſhewn.

20. The ſemicircular braſs wire that is ſuſpended over the Earth, repreſents the boundary of light and darkneſs thereon, for that half of the Earth on that ſide of the wire which is next the Sun, is called, the enlightened Hemiſphere, and the half on the other ſide the darkened Hemiſphere.

21. The ſmall plain ivory ball, denotes the Moon, and is carried round the Earth in 29 ½ days, by means

of the braſs arm, that communicates with the wheel work in the frame. For one revolution of the Earth round the Sun, this Moon goes 12 times and one third round the Earth, the ſame as the Moon in the Heavens. The Moon is fixed on a wire, which moves up and down in a ſocket at the arm before mentioned, ſo that the moon may have her proper inclined motion in reſpect to the Earth's given her by the help of a

22. Flat braſs open rim, C. D. fixed under the Earth, moveable two ways, viz. either horizontally, or vertically, ſo that when any inclination is given to this rim or orbit of the Moon, any poſition of this inclination may be given to it, and by that the exact inclined motion of the Moon in her orbit is repreſented, as alſo the Moon's Nodes; for that joint of the rim where it cauſes the Moon to begin to aſcend above the orbit of the Earth, is called the aſcending Node, and the oppoſite joint of the rim the deſcending Node: theſe two Nodes in the Heavens have a retrogade motion through the Signs of the Ecliptic in 19 years, The true poſition of them for any particular time may eaſily be found, as their places in the Ecliptic are in the Ephemeris, for the given year, and their places may be ſet in the Orrery accordingly, by means of another

23. Rim, E. F. fixed under the one above mentioned, having all the Signs and Degrees of the Ecliptic inſerted on it, which Signs the learner ſhould know by heart, ſo as to call them by their names when ſeen. This Ecliptic circle alſo ſerves to ſhew the Moon's place in the Heavens, as ſeen from the Earth, and alſo the diſtance from the Sun that ſhe appears to have at any ſituation of her in her orbit; for this Ecliptic

as well as the orbit of the Moon, and the Earth, keeps its paralleliſm, or all the Signs and Degrees parallel to thoſe on the board, in its revolution round the Sun, with the Earth.

24. Under the above two circles, is a Card, or Plate, which is fixed to the frame of wheels by two ſcrews; this card has the age and phaſes of the Moon on it, with the initial letters N. M. 1 Qr. F. M. 3 Qr. ſignifying, that when the wire arm that carries round the Moon is over any of theſe letters, it is according to the letters the wire is over, either New Moon, the firſt quarter of the Moon; Full Moon, or the third or laſt Quarter of the Moon; alſo, when the above arm is over any Phaſe and Number, it ſhews the quantity of light on the Moon that appears to the Earth at the age there figured.

25. The ſmall tin lacquered lamp (L) given with the Orrery, is to be lighted with oil, and a very ſlender wick of cotton, then to be placed on the wire, that the braſs ball denoting the Sun is ſcrewed to, which braſs ball muſt be unſcrewed, and the ſocket at the bottom of the lamp put on in the room of it; when the lamp is uſed, the room where the Orrery is uſed ſhould be made quite dark. This lamp has an excellent effect in the uſe of the Orrery, for all the Phænomena it is capable of repreſenting are, as it were realized by the light of the artificial Sun.

Having deſcribed the component parts, we now proceed to the uſe of it, wherein I ſhall give only a few examples, for there are a great many particulars to be ſhewn by it, which the learner will perceive as he encreaſes his knowledge in Aſtronomy, but could not be included in this ſmall tract.

26 The firſt thing neceſſary in the uſe of the Tellurian is, to rectify it, which is done by the following means.

At the end of the frame neareſt the Sun, is a long braſs wire, ſerving as an Index to point out the ſeveral places of the Sun, as he appears to move through by the Earth's annual motion, ſo that when this Index points out the Sun in any particular ſign and degree, it is evident that the place of the Earth is in the oppoſite ſign and degree of the Ecliptic; as for example, lay hold of the round ſhoulder turned on the under ſide of the board with one of your hands, or place the board ſteady on a table, and then with the other hand turn the frame of wheels round, by a ſmall ivory handle (H) fixed on the end of the frame fartheſt from the Sun, 'till the Index points to the 21ſt of June, or to the firſt degree of Cancer, which indicates that at that time of the year, the Sun appears to be in the beginning of Cancer, and the Earth in the beginning of the oppoſite ſign, viz. Capricorn, obſerving at the ſame time, if the ſign of Cancer and Capricorn on the board are in a line with the ſigns Cancer and Capricorn on the ſmall Ecliptic under the Earth; if not, move the ſmall Ecliptic about 'till they are ſo: obſerve alſo, that the inclination of the Earth's Axis is towards the ſign of Cancer, and if it is not, move its ſupporter round the ſteel wire until it is ſo; then turn the frame round, until the Index points to the day of the month you would rectify it for; as ſuppoſe now for June 1ſt, 1782, the Index ſhews that the Sun is then in the 10th of Gemini, and conſequently the Earth in the 10th of Sagittarius; then looking in an Ephemeris or Almanack for the given year, for the place or age of the Moon, we find that the place of the Moon is in the

24th of Aquarius, and her age is 20 days, which place or age ſet in the ſmall Ecliptic (ſee § 23) or the Card (ſee § 24). The place of the Moon's Aſcending Node I alſo find in the Ephemeris is in the 13th degree of Aries, I then bring the middle or axis of one of the joints of the flat rim (ſee § 22) over that degree and ſign, in the ſmall ecliptic, and elevate the rim in ſuch a manner that the half of it which is over Aries, Taurus, Gemini, &c. may be about a quarter of an inch higher than the other half, eſtimating at thoſe parts of the rim that are fartheſt from the joints, taking care that while the Moon and this rim are ſetting, the Earth is kept in the poſition as before ſet; then is the Orrery rectified for any paſt or future time, and ready to be put in motion, firſt acquainting the learner, that there is not to be expected any calculations from it, the ſmallneſs of the ſize not admitting it to be done with any accuracy, being only practicable on the large Orreries, Globes, &c. *

27. Still keeping the Earth in the above poſition; turn it round its Axis, with your finger, the ſame way as the order of the ſigns is: this motion will then repreſent the daily motion of the real Earth round the imaginary Axis (ſee § 10, Part I. and § 16, of this) in 24 hours. As you keep turning the Earth, the braſs piece denoting London, will when in the middle of the enlightened half of the Earth, ſhew, that the Sun is then on the Meridian, or it is Noon; but as you keep turning the Earth, London will be brought to

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* As many gentlemen and ladies wou'd wiſh to be poſſeſſed of the large and complete Orreries, Planetariums, Cometariums, &c. as contrived by the late Meſſrs. Ferguſon and Martin; this is to inform them, that they are accurately made and ſold by me as before directed

to the boundary wire, the Sun then to the Londoners is beginning to ſet, and when London is paſt the wire the Sun is quite ſet, it being to them evening, and conſequently in darkneſs; when it is in the middle of the other Hemiſphere, it is to them midnight, but arriving at the other ſide of the boundary wire, the Sun begins to riſe, and London then enters the enlightened Hemiſphere, called Morning; and ſo on as before. The different lengths of days and nights, will be explained in the following repreſentatiou of the four Seaſons, Spring, Summer, Autumn, and Winter.

16. Now move the frame of wheels on, according to the order of the months or ſigns, until the Index at the end of the frame points to the 20th of March, or the firſt degree of Aries, ſignifying that the Sun on the 20th of March, enters the ſign of Aries. Now looking at the Earth you will perceive that the Equator (ſee § 17, of this) is oppoſite to the center of the Sun, or that the Sun is over that part of the Ecliptic, which croſſes the Equa,or and aſcends to the Tropic of Cancer (§ 17 of this), and that the North Pole is exactly under the boundary wire; that the number of circles on each ſide of the wire is twelve, and by turning the Earth round its Axis we find that there is always that number, and as one half of the Earth is in the light, and the other half in darkneſs, conſequently on the 20th of March there is equal day and night all over the Earth; this is called the Vernal Equinox, and the ſeaſon of the year Spring.

17. Moving the frame gently on, you will perceive the North Pole to come more and more into the light, and the quantity of hour circles or Meridians between the Equator and the North Pole, to encreaſe, and

conſequently the length of days at that part of the Earth, thoſe having the longer days who live nearer the Pole. Turn the Earth round its Axis and you will ſee that the ſituations of London, at Sun-riſing and at Sun-ſetting, is at the diſtance nearly of 16 hours ½, and at Sun-ſetting to Sun-riſing about 7 ½, which is the length of day and night at this time of the year, at London, being the 21ſt of June; and as the Sun is over that part of the Ecliptic, which touches the tropic of Cancer, it is to the Northern Inhabitants the longeſt day and ſhorteſt night, and the middle of that ſeaſon of the year, called Summer.

30. Continuing to move the frame on, you will perceive part of the polar circle to retire under the boundary wire, until the 23d of September, or when by the Index the Sun enters Libra. On that day the poſition of the Earth is every way the ſame as it was on the 20th of March (ſee §28 of this) only at this time of the year it is called Autumn, or the Autumnal Equinox.

31. Proceed to move the frame on, in doing which the polar circle will be diminiſhing until the 21ſt of December, when the Sun enters Capricorn, and is over that part of the Ecliptic on the Earth, that touches the Tropic of Capricorn; when the North polar circle will be entirely in the dark hemiſphere, and the quantity of hour circles on the north-ſide of the Equator leſs in the enlightened hemiſphere than in the dark hemiſphere. The poſition and affections of the Earth this day are in all reſpects the reverſe of thoſe on the 21ſt of June, and the time of the year is called Winter.

32. Turning the frame 'till the Index points to the 20th of March, the year is then compleated, and the